



## Properties of Matter

Unit: Science , Grade(s) 7

In this unit, students explore some of the characteristic properties of matter and how those properties are affected by energy transfers and flow. Students are introduced to the particle theory of matter, which states that all matter is composed of extremely small components called particles. Students study how changing matter among the three phases of solid, liquid, and gas, involves changing the energy of the particles (therefore their motion and their spacing). The particle theory is also used to introduce the concept of density as a characteristic property of matter. Finally, students apply the particle theory to mixtures and solutions, identifying ways to separate the components of various mixtures as well as the role of temperature on solubility of materials.

Duration: 11 Weeks

### Unit

#### Big Ideas

##### 1. (January) Measurement:

- All matter has properties which can be observed and measured using laboratory instrumentation.
- Some properties of matter depend on the amount of matter present (e.g. mass, volume, temperature). Other properties are characteristic of matter--they are the same no matter how much matter there is (e.g. density).

##### 2. Particle Model of Matter:

- Matter is made up of tiny invisible units called particles.
- The increase or decrease of energy can affect the arrangement of particles in matter to cause a change in volume, density, or phase of matter.
- Adding or removing energy to matter changes the motion and the spacing of the particles. It does not change the size of the particles.

##### 3. Characteristic Properties of Matter/Density

- The density of matter is a characteristic property; that is, it does not depend on the amount of matter present.
- Since density is a characteristic property, it can be used to identify a substance.
- The density of objects determines their tendency to float or sink in other substances. An object will float on water if its density is less than that of water (1 g/ml). Likewise, an object will sink in water if its density is greater.

##### 4. (February) Heat and the Particle Model

- Solids, liquids, and gases all have mass, volume, and density, each of which can be measured or calculated.
- Particles in a solid have low energy, are packed close together, and exhibit little movement (mostly vibrational). Particles in a liquid have higher energy, are packed less tightly, and exhibit more movement (translational). Particles in a gas have high energy, are not packed tightly at all, and exhibit the most movement.

##### 5. Manufactured Items

- Synthetic materials and/or modified natural materials are produced to make products used in everyday life.
- Producing manufactured items does not result in an overall loss or gain in matter from the starting materials.

##### 6. (March) Solubility in Water

- Water is termed the "universal solvent" and dissolves many solids, liquids, and gases.
- Solutions are homogeneous mixtures of two or more components. The properties of a solution depend on the nature and concentration of the solute(s) and the nature of the solvent(s).
- When a solute dissolves in a solvent, the dissolved solute does not disappear but is added to the mass of the solvent. This is conservation of matter.



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### 7. Temperature and Solubility

- The rate of solubility is influenced by the temperature of the solute and solvent.
- Temperature of the solvent can affect the saturation point of the solution.

### 8. Separating the Parts of a Solution

- Matter can be divided into pure substances and mixtures. Mixtures can be heterogeneous or homogeneous and can be separated into their component substances by physical means (filtration, phase change). Pure substances cannot be separated into component parts by physical means.
- Most materials are physical mixtures consisting of different components in varying concentrations. The individual components can be separated using the components' unique physical properties.
- Solutions are homogeneous mixtures that generally require a phase change (e.g. evaporation, condensation) or selective adsorption to a medium (chromatography) to be separated into component parts.

### Enduring Understandings

- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying the explanation.
- The development of technology and advancement in science influence and drive each other forward.
- Understanding past processes and contributions is essential in building scientific knowledge.
- The structures of materials determine their properties.
- The properties of a mixture are based on the properties of its components.
- When materials interact within a closed system, the total mass of the system remains the same.
- People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.
- Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.

### Essential Questions

- What makes a question scientific?
- What constitutes evidence? When do you know you have enough evidence?
- Why is it necessary to justify and communicate an explanation?
- How do science and technology influence each other?
- How have past scientific contributions influenced current scientific understanding of the world?
- What do we mean in science when we say that we stand on the shoulders of giants?
- How do the properties and structures of materials determine their uses?
- How can the properties of the components of a mixture be used to separate the mixture?
- How do the components determine the properties of mixtures?
- How does conservation of mass apply to the interaction of materials in a closed system?
- How do you know which material is best for a particular product or need?
- What determines if new materials need to be developed?
- Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?
- What happens to a material when energy is transferred to it?

### Knowledge and Skills

- Forming a testable question
- Graphing/graph interpretation



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- laboratory skills
- measurement skills (mass, volume, length, temperature)
- safety training
- Internet research

### Assessment(s)

All assessments for this unit are available in SchoolNet as "linked resources."

1. Seventh grade assessment 19: Measurement.
2. Seventh grade assessment 20: Properties of Matter Assessment.
3. Seventh grade assessment 21: Characteristic Properties and Density
4. Seventh grade assessment 22: Density Column
5. Seventh grade assessment 23: Mass and Melting
6. Seventh grade assessment 24: Properties of Matter Anchor Activity, Lesson 10, pp. 123-133. Rubric is on p. 120 of Teacher's Manual, table 10.2.
7. Seventh grade assessment 25: Solubility in Water
8. Seventh grade assessment 26: Temperature and Solubility
9. Seventh grade assessment 27: Separating the Parts of a Solution

### Text Activities

This unit has no textbook for students. All activities and readings are taken from the following unit:

"Properties of Matter" Burlington, NC, Carolina Biological Supply Company, National Science Resources Center, Smithsonian/The National Academies, 2000.

### Additional Activities

1. Measurement (January)

#### Lesson 1: Our Ideas About Matter:

GOALS: In this lab activity students will

- observe some of the physical properties of matter in a variety of forms.
- practice making measurements with a variety of laboratory apparatus.
- Practice safe lab technique.

ACTIVITY OVERVIEW: a synopsis of this activity follows:

Students investigate some of the characteristics of matter through a series of short inquiry activities. Students practice determination of volume, mass, length, and temperature.

CONTEXT: The concepts we have been developing and how this activity serves as the next step can be explained as follows:



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Although this activity serves as the first inquiry into matter and particle theory, it represents a drastic change in the flow of information that has occurred up to this point. Students are given the opportunity to practice measuring, to make mistakes, and to observe matter in a variety of forms. Since Red Clay is latex free, do not have students perform Inquiry 1.1 The Bottle and the Balloon.

Science standards 6-8 addressed:

1.1.3: In a scientific investigation, data collection involves making precise measurements and keeping accurate records so that others can replicate the experiment.

1.1.6: Scientific habits of mind and other sources of knowledge and skills are essential to scientific inquiry. Habits of mind include tolerance of ambiguity, skepticism, openness to new ideas, and objectivity. Other knowledge and skills include mathematics, reading, writing, and technology.

### 2. Particle Model of Matter

#### SchoolNet Lesson--Properties of Matter--Flexible Grouping

GOALS: In this lab activity students will be able to

- Relate the particles in a solid, liquid, and gas to relative amounts of energy, movement, and spacing.
- Use a concrete representation to illustrate the Particle Model.

ACTIVITY OVERVIEW: a synopsis of this activity follows:

Students will watch a video clip illustrating the characteristics of the particles in a solid, a liquid, and a gas. Then, using marbles and a clear dish, they will illustrate the behavior of particles in a solid, a liquid, and a gas. Student groups will report out to the class.

CONTEXT: The concepts we have been developing and how this activity serves as the next step can be explained as follows:

Although the STC module "Properties of Matter" does not refer to it, the Particle Model of matter is a crucial piece to this unit in seventh and eighth grade (Transformation of Energy). Before students learn about atomic theory and the elements, it is crucial that a firm foundation in the Particle Model be understood, especially as the particles are affected by temperature. Students will use this model to describe phase changes, density, and dissolving. This unit does not address the concept of atoms, molecules, ions, compounds, or elements; in fact, these concepts are not addressed until ninth grade.

Science standards 6-8 addressed:

1.1.5: Evaluating the explanations proposed by others involves examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Conflicting data or conflicting interpretations of the same data suggest the need for further investigation. Continued investigation can lead to greater understanding and resolution of the conflict.

1.1.6: Scientific habits of mind and other sources of knowledge and skills are essential to scientific inquiry. Habits of mind include tolerance of ambiguity, skepticism, openness to new ideas, and objectivity. Other knowledge and skills include mathematics, reading, writing, and technology.

2.1.1 All matter consists of particles too small to be seen with the naked eye. The arrangement, motion, and interaction of these particles determine the three states of matter (solid, liquid, and gas). Particles in all three states are in constant motion. In the solid state, tightly packed particles have a limited range of motion. In the liquid state, particles are loosely packed and move past each other. In the gaseous state, particles are free to move.



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Seventh grade GLEs addressed:

- 7.1.d Form explanations based on accurate and logical analysis of evidence. Revise the explanation using alternative descriptions, predictions, models and knowledge from other sources as well as results of further investigation.
- 7.1.e Communicate scientific procedures, data, and explanations to enable the replication of results. Use computer technology to assist in communicating these results. Critical review is important in the analysis of these results.
- 7.1.f Use mathematics, reading, writing, and technology in conducting scientific inquiries.
- 7.2.a Recognize that all matter consists of particles and how the particles are arranged determines the physical state. Use the particle model to describe solids, liquids, and gases in terms of the packing and motion of particles.
- 7.2.d Make a model or drawing of particles of the same material in solid, liquid, and gas state. Describe the arrangement, spacing and energy in each state.

### 3. Density

#### Lesson 2: Determining Density

#### Lesson 3: Density Predictions

#### Lesson 4: Do Gases Have Density?

GOALS: In these lab activities the students will be able to

- Use laboratory apparatus to find the mass and volume of a known amount of water.
- Determine the volume of solid objects by calculating their volume (cubes) or by displacement of water (irregularly shaped objects)
- Determine the density of solids and liquids experimentally.
- Relate an object's density to its tendency to float or sink in a density column.
- Design an experiment to determine the mass, volume, and density of a volume of air.

ACTIVITY OVERVIEW: a synopsis of this activity follows:

In these three lessons, students are introduced to the concept of density (mass per unit volume) as a characteristic property of matter. In Lesson 2, they determine the density of various liquids and solid objects by determining (through a variety of strategies) the mass (in grams) and the volume (in ml) and dividing mass by volume. In Lesson 3, students relate the density of an object or fluid to its tendency to float on or sink in a substance of a different density. The concept of miscibility is introduced but not explored until later in the unit. In Lesson 4, students apply the techniques for measuring density (i.e. mass and volume) to the question of how to measure the mass and volume (therefore, the density) of a gas (air).

CONTEXT: The concepts we have been developing and how this activity serves as the next step can be explained as follows:

Density is a difficult concept in science. This is the second time students have worked with a derived unit (in Forces that Cause Motion in sixth grade, they learn about speed as a measure of distance divided by time). Students harbor many misconceptions about density (see p. 17 of the Properties of Matter Teacher's Guide). It is necessary to assess exactly which misconceptions your students may have about density and differentiate your instruction toward creating an accurate understanding of density. Density will be revisited in the Weather unit in eighth grade, as students study the density of air layers in convection currents. In ninth grade, students will explore the idea of density as a characteristic property of matter further (specifically, elements and compounds).

Science standards 6-8 addressed:



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1.1.1. Scientific investigations involve asking testable questions. Different kinds of questions suggest different scientific investigations. The current body of scientific knowledge guides the investigation.

1.1.3. In a scientific investigation, data collection involves making precise measurements and keeping accurate records so that others can replicate the experiment.

1.2.1. Advances in technology can expand the body of scientific knowledge. Technological tools allow people to observe objects and phenomena that otherwise would not be possible. Technology enhances the quality, accuracy, speed and analysis of data gathered.

2.1.3. Some physical properties, such as mass and volume, depend upon the amount of material. Other physical properties, such as density and melting point, are independent of the quantity of material. Density and melting point are unique physical properties for a material. Tools such as microscopes, scales, beakers, graduated cylinders, Celsius thermometers, and metric rulers are used to measure physical properties.

### Seventh grade GLEs

7.1.c. Accurately collect data through the selection and use of tools and techniques appropriate to the investigation. Construct tables, diagrams and graphs, showing relationships between two variables, to display and facilitate analysis of data. Compare and question results with and from other students.

7.2.e Distinguish between physical properties that are dependent upon mass (size, shape) and those physical properties such as boiling point, melting point, solubility, density, conduction of heat and pH of a substance or material that are not altered when the mass of the material is changed.

7.2.f. Calculate the density of various solid materials. Use density to predict whether an object will sink or float in water. Given the density of various solids and liquids, create a density column and explain the arrangement in terms of density.

### 4. Heat and the Particle Model (February)

#### Lesson 5: Temperature and Density

#### Lesson 7: Just a Phase

#### Lesson 8: Changing Matter and Mass

GOALS: In these lab activities students will be able to

- describe how increasing the heat of a substance (without changing its phase) affects its volume (and therefore, its density).
- explore how the temperature of a substance undergoing a phase change varies with time.
- distinguish between heat and temperature.
- describe how changing the phase of matter in a closed system affects its total mass.

ACTIVITY OVERVIEW: a synopsis of this activity follows:

In Lesson 5, students create a water thermometer to explore the effects of changing temperature on the density of water in a closed system. In Lessons 7 and 8, students change water from a solid to a liquid and observe how the temperature varies (they see that during the actual phase change, the temperature stays the same, as the ice gains the necessary heat to melt) and how the mass changes (it doesn't).

CONTEXT: The concepts we have been developing and how these activities serve as the next step may be explained as follows:

This set of activities extends the concept of density by addressing how density of a substance is affected by temperature. The



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effects of energy transfer on matter is addressed throughout all the science units. Although the effect of phase changes on density is not specifically addressed in this unit, students do address how changing the phase of matter affects and is affected by temperature. Through these activities, they discover that heat and temperature are not the same. Heat represents the total kinetic energy of particles. Heat is determined by the amount of a substance. Temperature is an average measure of kinetic energy. While temperature is not a characteristic property, it is not dependent on the quantity of matter. Lesson 8 introduces the important concept of conservation of mass. Students in seventh grade are usually secure that changing the shape of an object does not change its mass. However, they may not be as sure that changing the phase of a substance does not change its mass. Lesson 8 shows them that the only way to change the mass of an object is to add matter to it.

Science standards 6-8 addressed:

1.1.2. A valid investigation controls variables. Different experimental designs and strategies can be developed to answer the same question.

1.1.6. : Scientific habits of mind and other sources of knowledge and skills are essential to scientific inquiry. Habits of mind include tolerance of ambiguity, skepticism, openness to new ideas, and objectivity. Other knowledge and skills include mathematics, reading, writing, and technology.

1.2.1 Advances in technology can expand the body of scientific knowledge. Technological tools allow people to observe objects and phenomena that otherwise would not be possible. Technology enhances the quality, accuracy, speed and analysis of data gathered.

1.2.2. Science and technology in society are driven by the following factors: economical, political, cultural, social, and environmental. Increased scientific knowledge and technology create changes that can be beneficial or detrimental to individuals or society through impact on human health and the environment.

2.1.2. A phase change may occur when a material absorbs or releases heat energy. Changes in phase do not change the particles but do change how they are arranged.

2.1.3. Some physical properties, such as mass and volume, depend upon the amount of material. Other physical properties, such as density and melting point, are independent of the quantity of material. Density and melting point are unique physical properties for a material. Tools such as microscopes, scales, beakers, graduated cylinders, Celsius thermometers, and metric rulers are used to measure physical properties.

2.1.5 Exposure to energy, such as light and heat, may change the physical properties of materials.

2.3.1. The total mass of the mixture is equal to the sum of the masses of the components. Total mass is conserved when different substances are mixed.

Seventh grade GLEs addressed:

7.1.b Design and conduct investigations with controlled variables to test hypotheses.

7.1.c. Accurately collect data through the selection and use of tools and techniques appropriate to the investigation. Construct tables, diagrams and graphs, showing relationships between two variables, to display and facilitate analysis of data. Compare and question results with and from other students.

7.2.b. Measure and record the temperature of ice water as it is heated. Plot the graph of measurements taken and interpret the



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change of phase graph using the particle model, identifying the states of matter.

7.2.c. Analyze a standard change of phase graph of water. Using the particle model, identify where water is a solid, liquid or gas, is freezing/melting or evaporating/condensing. Relate the states of matter to the changes (increase, decrease) of energy in the system.

### 5. Manufactured Items

#### Lesson 10: Anchor Activity--Manufactured Item research

GOALS: In this activity students will be able to

- Connect the properties of matter discussed so far to an actual manufactured item.
- Determine the rationale behind what the item is made from.
- Conduct research using books, magazines, the Internet, and other useful resources.

ACTIVITY OVERVIEW: a synopsis of this activity follows:

In this activity, students choose a manufactured item to research and prepare a report on the item, its history, the raw materials that make it up, and how those materials are prepared to make the object. The final project is a written report about the object, its function, its component materials, and properties of those materials.

CONTEXT: The concepts we have been developing and how this activity serves as the next step can be explained as follows:

This activity serves as a capstone for the work done in Properties of Matter thus far. It can be assigned any time after this unit has begun, and may be done individually or in pairs. Its purpose is to illustrate how society values an understanding of what matter is and how it is manipulated.

Science standards 6-8 addressed:

1.1.4: There is much experimental and observational evidence that supports a large body of knowledge. The scientific community supports known information until new experimental evidence arises that does not match existing explanations. This leads to the evolution of the scientific body of knowledge.

1.1.6. Scientific habits of mind and other sources of knowledge and skills are essential to scientific inquiry. Habits of mind include tolerance of ambiguity, skepticism, openness to new ideas, and objectivity. Other knowledge and skills include mathematics, reading, writing, and technology.

1.2.1 Advances in technology can expand the body of scientific knowledge. Technological tools allow people to observe objects and phenomena that otherwise would not be possible. Technology enhances the quality, accuracy, speed and analysis of data gathered.

1.2.2. Science and technology in society are driven by the following factors: economical, political, cultural, social, and environmental. Increased scientific knowledge and technology create changes that can be beneficial or detrimental to individuals or society through impact on human health and the environment.

1.3.1 Over the course of human history, contributions to science have been made by different people from different cultures. Studying some of these contributions and how they came about provides insight into the expansion of scientific knowledge.

2.5.1 Synthetic materials and/or modified natural materials are produced to make products used in everyday life.





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2.5.2. The production of new materials has social, environmental, and other implications that require analysis of the risks and benefits.

Seventh grade GLEs addressed:

7.1.e. Communicate scientific procedures, data, and explanations to enable the replication of results. Use computer technology to assist in communicating these results. Critical review is important in the analysis of these results.

7.1.f. Use mathematics, reading, writing, and technology in conducting scientific inquiries.

7.2.n. Select a manufactured item and identify its component materials. Explain how the physical properties of the materials contribute to the function of the item

7.2.o. Discuss the social, economic, and/or environmental consequences of the production of new materials to meet human wants and needs.

### 6. Solubility in water

Lesson 11: Pure Substance or Mixture?

Lesson 12: What Happens When Substances are Mixed with Water?

Lesson 13: How Much Solute Dissolves in a Solvent?

Lesson 14: Mass, Volume, and Dissolving

**GOALS:** In these lab activities students will be able to:

- Distinguish a pure substance from a mixture, and classify a mixture as homogeneous or heterogeneous.
- Identify whether substances are soluble or insoluble in water and classify substances by their relative solubilities in water.
- Describe what is meant by a saturated solution and determine the saturation point of a solute in water.
- Describe what happens to the total mass and total volume of a system when a solute (solid or liquid) is dissolved in water.

**ACTIVITY OVERVIEW:** a synopsis of this activity follows:

In all of these activities, students are introduced to the concepts of mixtures as combinations of particles. In Lesson 11, a mixture is compared to a pure substance. Mixtures are also classified as homogeneous and heterogeneous. Students observe a variety of substances, including rocks (granite and slate), shaving cream, and solutions. In Lessons 12 and 13, students ask the question, "what dissolves in water?" They classify materials in terms of whether they dissolve in water, and identify the saturation point of a solute in water. In Lesson 14, the conservation of mass concept is revisited in terms of combining a solute with a solvent.

**CONTEXT:** the concepts we have been developing and how these activities serve as the next step can be explained as follows:

The second half of Properties of Matter is devoted to mixtures and solutions. In Lessons 11 and 12, no distinction is made between an element and a compound; both are listed as "pure substances." The distinction between homogeneous and heterogeneous mixtures is determined by particle size. The more widely distributed the particles are, the more homogeneous the mixture will be. The importance of mixing will be addressed in Watersheds under soil porosity. Lessons 12 and 13 establish water solubility as a characteristic property (like density) of matter. Oil does not dissolve in water in any amount. It is a good idea at this point to revisit the density column and the term "miscible," since dissolving makes it difficult to use a density column (more advanced students may be able to devise a strategy for determining the volume of a soluble solid like salt). Lesson 14 reinforces the idea that combining a solute with a solvent does not add or remove matter (hence, the total mass is the sum of the masses of the components). This activity targets a common misconception of students that the solute "disappears" in the solvent.

Science standards 6-8 addressed:



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1.1.1. Scientific investigations involve asking testable questions. Different kinds of questions suggest different scientific investigations. The current body of scientific knowledge guides the investigation.

1.1.2. A valid investigation controls variables. Different experimental designs and strategies can be developed to answer the same question.

1.1.3. In a scientific investigation, data collection involves making precise measurements and keeping accurate records so that others can replicate the experiment.

1.1.6. Scientific habits of mind and other sources of knowledge and skills are essential to scientific inquiry. Habits of mind include tolerance of ambiguity, skepticism, openness to new ideas, and objectivity. Other knowledge and skills include mathematics, reading, writing, and technology.

2.2.1. Mixtures can be homogeneous or heterogeneous. Mixtures may be solids, liquids, and/or gases. Most materials are physical mixtures consisting of different components in varying concentrations. The individual components can be separated using the components' unique physical properties.

2.2.2. Solutions are homogeneous mixtures of two or more components. The properties of a solution depend on the nature and concentration of the solute(s) and the nature of the solvent(s).

2.2.3. The rate of solubility is influenced by temperature and the surface area of the solute.

Seventh grade GLEs addressed

7.1.a Frame and refine questions that can be investigated scientifically, and generate testable hypotheses.

7.1.b Design and conduct investigations with controlled variables to test hypotheses.

7.1.c Accurately collect data through the selection and use of tools and techniques appropriate to the investigation. Construct tables, diagrams and graphs, showing relationships between two variables, to display and facilitate analysis of data. Compare and question results with and from other students.

7.1.d. Form explanations based on accurate and logical analysis of evidence. Revise the explanation using alternative descriptions, predictions, models and knowledge from other sources as well as results of further investigation.

7.2.h Distinguish between homogeneous and heterogeneous mixtures. Using their physical properties, design and conduct an investigation to separate the components of a homogeneous or heterogeneous mixture. Recognize that a homogeneous mixture is a solution.

7.2.i Prepare solutions of different concentrations recognizing that the properties of the solution (color, density, boiling point) depend on the nature and concentration of the solute and solvent.

7.2.j. Conduct investigations to determine the effect of temperature and surface area of the solute on the rate of solubility. Describe the rate of solubility using the particle model.

7. Temperature and Solubility

Lesson 18: Changing Materials



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GOALS: In this lab activity students will be able to

- determine the effect of temperature on the solubility of a solid in water.

ACTIVITY OVERVIEW: a synopsis of this activity follows:

In this activity, students explore the effect of solvent temperature on the solubility of salt to water. They determine the solubility of salt in ice water and in boiling water.

CONTEXT: The concepts we have been developing and how this activity serves as the next step can be explained as follows:

This activity extends the concept of solubility and saturation to the effects of temperature on solubility. This activity only considers solid solutes. It may be wise, however, to introduce the question of gaseous solutes and how temperature affects solubility of a gas, since this topic is important in Watersheds with dissolved oxygen. In both cases, the particle model explains the behavior of solute. With a solid solute, the particles move more with increased temperature and tend to disperse throughout the solvent more easily than they do in lower temperatures. With a gaseous solute, the particles disperse so much that they are likely to escape the solvent into the air. Applications of the role of temperature on solubility include using road salt on ice in the winter, adding anti-freeze/coolant to the radiator, and the effects of temperature on dissolved oxygen in water.

Science standards 6-8 addressed:

2.2.3. The rate of solubility is influenced by temperature and the surface area of the solute.

2.2.4. Temperature of the solvent can affect the saturation point of the solution.

Seventh grade GLEs addressed:

7.2.j Conduct investigations to determine the effect of temperature and surface area of the solute on the rate of solubility. Describe the rate of solubility using the particle model.

7.2.k. Conduct investigations to determine the effect of temperature on saturation point. Construct a solubility curve based on data collected. Describe solubility and saturation point using the particle model.

8. Separating Parts of a Solution

Lesson 15: Separating a Soluble and an Insoluble Substance

Lesson 17: Separating Solutes

GOALS: In these lab activities students will be able to

- Identify which mixtures can be separated by ordinary physical means (e.g. filtration, sedimentation) and employ these means successfully.
- Identify which mixtures must be separated by using a phase change (e.g. evaporation).
- Describe a procedure to separate and collect the components of a mixture.
- Use chromatography to separate and identify several solutes in a solution.

ACTIVITY OVERVIEW: a synopsis of these activities follows:



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Both of these activities are focused on separating a mixture into its component parts. In Lesson 15, students separate an insoluble solid from a liquid using filter paper. They also devise a procedure for separating a dissolved solute from its solvent after learning that filtration will not accomplish this task. They are required to focus on collecting the desired component as well as separating it. In Lesson 17, students separate different colors of ink from a mixture using paper chromatography. This technique involves separating the component inks by adsorbing them to paper. Different inks adsorb to paper at different concentrations.

CONTEXT: the concepts we have been developing and how this activity serves as the next step can be explained as follows:

This final activity of Properties of Matter focuses on mixtures and solutions in reverse. Rather than creating a mixture, students are asked to separate the parts of a mixture into pure substances. Although the unit places this activity before Lesson 18, by placing it Lesson 18, students can explore using temperature change as a method for separating parts of a mixture. Students should discover that salt water cannot be made fresh by filtration. Also, if the goal is to purify the water, students should also consider that evaporation of water is not enough--a plan for collecting evaporated water (through condensation) should be proposed. This activity can be revisited in Watersheds during the Water on the Earth topic. The chromatography lesson is optional, but it is a dramatic illustration of how inks may be separated. Students with an interest in forensic science will find the chromatography unit interesting. This same strategy is used in tenth grade to separate DNA molecules.

Science standards 6-8 addressed:

1.1.1. Scientific investigations involve asking testable questions. Different kinds of questions suggest different scientific investigations. The current body of scientific knowledge guides the investigation.

1.1.2. A valid investigation controls variables. Different experimental designs and strategies can be developed to answer the same question.

1.1.3. In a scientific investigation, data collection involves making precise measurements and keeping accurate records so that others can replicate the experiment.

2.2.1. Mixtures can be homogeneous or heterogeneous. Mixtures may be solids, liquids, and/or gases. Most materials are physical mixtures consisting of different components in varying concentrations. The individual components can be separated using the components' unique physical properties.

2.2.3. The rate of solubility is influenced by temperature and the surface area of the solute.

Seventh grade GLEs addressed:

7.1.a Frame and refine questions that can be investigated scientifically, and generate testable hypotheses.

7.1.b Design and conduct investigations with controlled variables to test hypotheses.

7.1.c Accurately collect data through the selection and use of tools and techniques appropriate to the investigation. Construct tables, diagrams and graphs, showing relationships between two variables, to display and facilitate analysis of data. Compare and question results with and from other students.

7.2.h Distinguish between homogeneous and heterogeneous mixtures. Using their physical properties, design and conduct an investigation to separate the components of a homogeneous or heterogeneous mixture.



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### Vocabulary

#### 1. Measurement

characteristic property: An attribute that can be used to help identify a substance. A characteristic property is not affected by the amount or shape of a substance.

gas: A phase of matter in which a substance has no definite shape or volume. Gases fill the container they occupy.

gram: A metric unit used to measure mass. Approximately the mass of one kidney bean.

liquid: A phase of matter in which a substance has a definite volume but no definite shape. Liquids take the shape of that part of the container they occupy.

mass: A measure of the total amount of matter in an object.

material: the substance from which an object is made.

matter: Anything in the universe that has mass and takes up space.

solid: A phase of matter in which a substance has a definite shape (which is not dependent on its container) and volume.

substance: a physical description of a type of matter.

temperature: A measure of how hot an object or substance is.

volume: The amount of space occupied by a sample of matter.

#### 2. The Particle Model of Matter

energy: the ability of particles or objects to do work or exhibit motion.

model: a concrete description or analogy of an abstract concept. The model is not meant to be an exact representation of the abstract concept, but rather, to illustrate specific aspects of the abstract concept.

particle: an indivisibly small unit of matter.

#### 3. Characteristic Properties and Density

density: The mass of a known volume of a substance. (Note: the unit for density is grams per ml of a substance. Compare this with the unit for concentration).

miscible: a property of two or more liquids. Miscible liquids can dissolve one another. Immiscible liquids cannot dissolve one another--they form distinct layers.

weight: A measure of the force of gravity. On Earth, the weight of an object is affected only by its mass.

#### 4. Heat and the Particle Model

Celsius: a temperature scale in which 0 degrees is the freezing temperature of water and 100 degrees is the boiling temperature of water.

condensation: a process by which a gas becomes a liquid or solid.

evaporation: a process by which a liquid becomes a gas.



## Unit

Fahrenheit: A temperature scale in which 32 degrees is the freezing temperature of water and 212 degrees is the boiling temperature of water.

freezing: a process by which a liquid becomes a solid.

phase (of matter): a description of the physical arrangement of particles of matter. The three familiar phases are solid, liquid, and gas.

### 5. Manufactured items

artificial: made by people

manufactured item: an item or substance that is produced by people (as opposed to found in nature).

synthetic: manufactured.

### 6. Solubility in Water

composite: a synthetic material made from two or more substances.

concentration: referring to a solution, the amount of solute dissolved in a given volume of solvent (note: the units for concentration are grams solute per ml solvent. Compare this to the unit for density)

dissolve: to mix two or more substances together and create a solution.

heterogeneous: referring to a mixture, having a variable composition throughout.

homogeneous: referring to a mixture, having the same general composition throughout. Solutions are homogeneous mixtures, but not all homogeneous mixtures are solutions (e.g.: milk).

mixture: two or more substances that are physically combined. A mixture can be separated by physical means.

saturation: referring to a solution, the largest mass of solute that can be dissolved in a given volume of solvent.

soluble: the ability of a solute to dissolve into a solvent. The opposite is "insoluble."

solute: a substance that dissolves in a solvent. By convention, "solute" refers to the component (solute vs. solvent) in lower concentration.

solution: a homogeneous mixture in which the smallest particles of the substances are mixed.

solvent: a substance that dissolves a solute. By convention, "solvent" refers to the component (solute vs. solvent) in highest concentration. A solution may have many solutes but only one solvent.

### 8. Separating Parts of a Mixture

adsorption: the process in which particles adhere to a surface.

alloy: a solid solution consisting of two metals or a metal and a nonmetal.

chromatography: a process used to separate different solutes from a solution by passing them through a medium.

component: a part of a mixture. Sometimes called "component part."

filtration: the process of separating a solid and a liquid by passing a mixture of the two through a screen (filter). Filtration is only effective if the solid is insoluble in the liquid.



## Unit

## Standards Covered

### SCI.7.1 Nature and Application of Science and Technology

- SCI.7.1.1 Understandings and Abilities of Scientific Inquiry
  - SCI.7.1.1.1 Understand that: Scientific investigations involve asking testable questions. Different kinds of questions suggest different scientific investigations. The current body of scientific knowledge guides the investigation.
  - SCI.7.1.1.2 Understand that: A valid investigation controls variables. Different experimental designs and strategies can be developed to answer the same question.
  - SCI.7.1.1.3 Understand that: In a scientific investigation, data collection involves making precise measurements and keeping accurate records so that others can replicate the experiment.
  - SCI.7.1.1.4 Understand that: There is much experimental and observational evidence that supports a large body of knowledge. The scientific community supports known information until new experimental evidence arises that does not match existing explanations. This leads to the evolution of the scientific body of knowledge.
  - SCI.7.1.1.5 Understand that: Evaluating the explanations proposed by others involves examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Conflicting data or conflicting interpretations of the same data suggest the need for further investigation. Continued investigation can lead to greater understanding and resolution of the conflict.
  - SCI.7.1.1.6 Understand that: Scientific habits of mind and other sources of knowledge and skills are essential to scientific inquiry. Habits of mind include tolerance of ambiguity, skepticism, openness to new ideas, and objectivity. Other knowledge and skills include mathematics, reading, writing, and technology.
- SCI.7.1.2 Science, Technology, and Society
  - SCI.7.1.2.1 Advances in technology can expand the body of scientific knowledge. Technological tools allow people to observe objects and phenomena that otherwise would not be possible. Technology enhances the quality, accuracy, speed and analysis of data gathered.
  - SCI.7.1.2.2 Science and technology in society are driven by the following factors: economical, political, cultural, social, and environmental. Increased scientific knowledge and technology create changes that can be beneficial or detrimental to individuals or society through impact on human health and the environment.
- SCI.7.1.2 History and Context of Science
  - SCI.7.1.3.1 Over the course of human history, contributions to science have been made by different people from different cultures. Studying some of these contributions and how they came about provides insight into the expansion of scientific knowledge.

### SCI.7.2 Materials and Their Properties

- SCI.7.2.1 Properties and Structure of Materials
  - SCI.7.2.1.1 All matter consists of particles too small to be seen with the naked eye. The arrangement, motion, and interaction of these particles determine the three states of matter (solid, liquid, and gas). Particles in all three states are in constant motion. In the solid state, tightly packed particles have a limited range of motion. In the liquid state, particles are loosely packed and move past each other. In the gaseous state, particles are free to move.
  - SCI.7.2.1.2 A phase change may occur when a material absorbs or releases heat energy. Changes in phase do not change the particles but do change how they are arranged.
  - SCI.7.2.1.3 Some physical properties, such as mass and volume, depend upon the amount of material. Other physical properties, such as density and melting point, are independent of the quantity of material. Density and melting point are unique physical properties for a material. Tools such as microscopes, scales, beakers, graduated cylinders, Celsius thermometers, and metric rulers are used to measure physical properties.
  - SCI.7.2.1.5 Exposure to energy, such as light and heat, may change the physical properties of materials.
- SCI.7.2.2 Mixtures and Solutions
  - SCI.7.2.2.1 Mixtures can be homogeneous or heterogeneous. Mixtures may be solids, liquids, and/or gases. Most materials are physical mixtures consisting of different components in varying concentrations. The individual components can be separated using the components' unique physical properties.
  - SCI.7.2.2.2 Solutions are homogenous mixtures of two or more components. The properties of a solution depend on the nature and concentration of the solute(s) and the nature of the solvent(s).
  - SCI.7.2.2.3 The rate of solubility is influenced by temperature and the surface area of the solute.
  - SCI.7.2.2.4 Temperature of the solvent can affect the saturation point of the solution
- SCI.7.2.3 Conservation of Matter
  - SCI.7.2.3.1 The total mass of the mixture is equal to the sum of the masses of the components. Total mass is conserved when different substances are mixed.
- SCI.7.2.5 Materials Technology



## Standards Covered

- SCI.7.2.5.1 Synthetic materials and/or modified natural materials are produced to make products used in everyday life.
- SCI.7.2.5.2 The production of new materials has social, environmental, and other implications that require analyses of the risks and benefits.
- SCI.7.3 Energy and its Effects
  - SCI.7.3.1 The Forms and Sources of Energy
    - SCI.7.3.1.4 Heat energy comes from the random motion of the particles in an object or substance. Temperature is a measure of the motion of the particles. The higher the temperature of the material, the greater the motion of the particles.
  - SCI.7.3.2 Forces and the Transfer of Energy
    - SCI.7.3.2.6 The addition or removal of heat energy from a material changes its temperature or its physical state.

## Materials

For a closer look at the materials list below, log onto <http://redclay.schoolnet.escholar.com>

### Resources:

1. Gases Inspiration Template
2. Gases Video
3. Liquid Inspiration Template
4. Liquids Video
5. Matter Assessment
6. Solids Inspiration Template
7. Solids Video
8. Water as a Solid, Liquid and a Gas

## Additional Properties

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